Space Weather Technical Forecast

Issued on Thursday, 29 September 2022 at 13:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2/Minor-Moderate geomagnetic storms likely to develop from late day 2 (30th) or day 3 (1st). Chance of G3/Strong from CME arrival on day 3 (1st).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with only minor C-class flares, the largest was a C5.6 observed at 29/0530 UTC, appears to have originated from around the northeast limb. However, these have been decreasing in frequency compared to recent days.

There are currently four numbered sunspots on the visible disc. AR3105 Cao/Beta and AR3107 Cao/Beta have continued to gradually decline as they move across the southwest disc. A small flux emergence has continued to gradually develop into visible spots to the west of the leader of AR3110 Cho/Beta-Gamma, but otherwise remains stable. AR3111 Hsx/Alpha remains a small and simple uni-polar spot. Some magnetic looping remains visible in SDO imagery over the northeast limb, which is associated with Ex-3098, and this will need monitoring for any further development. A filament eruption to the southeast of AR3110 was observed around 28/0400 UTC, with the associated CME having been assessed as potentially having an Earth-directed component.

Solar Wind / Geomagnetic Activity: Solar wind parameters show easing CME and fast wind influences. Solar wind speed, as measured by DSCOVR at L1, has declined from 550km/s (Elevated) to around 460km/s (slightly elevated), before rising to become elevated at around 520km/s at time of writing. The density was near to or below average, briefly rising to above average towards the end of the period. The total Interplanetary magnetic field strength, Bt, was weak, peaking at 7nT. The north-south component, Bz, stayed largely positive, ranging +5nT to -4nT. The phi angle was mostly negative (towards from the Sun). Geomagnetic activity was Quiet (Kp 0 to 2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16, was at or near background levels. High energy electron flux (greater than 2 MeV) was at background levels. The associated 24-hour fluence remained below the Active (1e8 integrated pfu) threshold. Observed fluence at 29/0000UTC was 1.25e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is forecast to be generally Low, with only a slight chance of isolated M-class flares.

Solar Wind / Geomagnetic Activity: The CME from the filament eruption on 28/0400 UTC has the potential to move across Earth on day 3 (1st). Solar winds are expected to be easing day 1 (29th), before the next coronal hole fast wind arrival from CH27/+ and CH28/+ later day 2 and during day 3 (30th and 1st). These fast winds persisting into day 4 (2nd). Quiet geomagnetic

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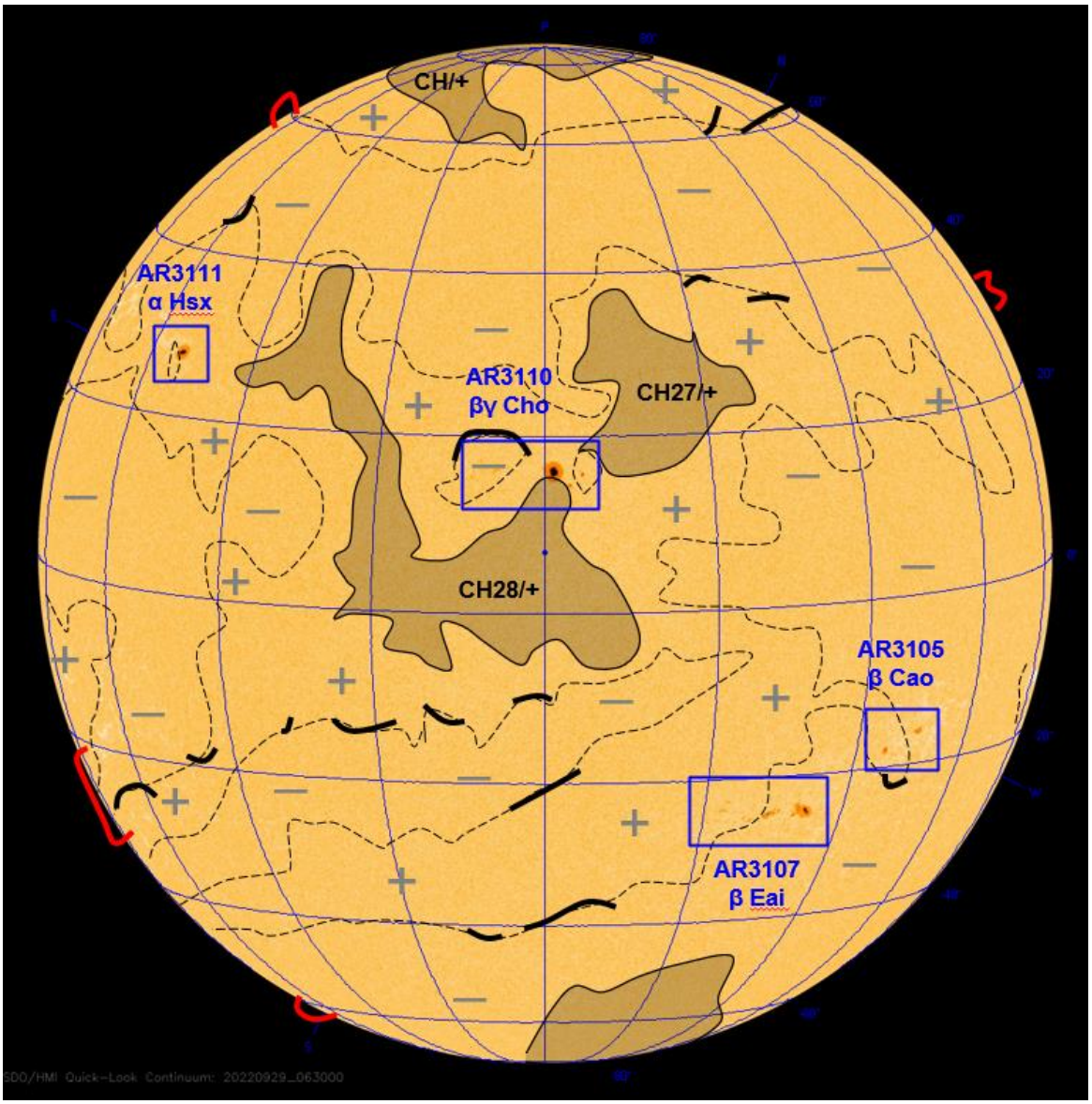
activity with Unsettled intervals possible at first, likely increasing to G1/Minor to G2/Moderate storm with the arrival of the fast wind on day 2 (30th). This may then increase further day 3 (1st Oct) from any CME arrival, with a chance of G3/Strong Storms. Activity easing to Quiet to Active day 4 (2nd), but still a chance of further G1/Minor Storms.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to persist at background levels. The high energy (greater than 2MeV) electron flux will likely remain at mostly background initially, but likely rising to High day 3 and 4 (1st and 2nd) in response to the fast wind arrival. There is some uncertainty however, due to the potential CME arrival day 3 (1st). The associated 24 hour fluence is likely to rise in response, and exceeding the Active threshold on day 4 (2nd).

Figure 1. Solar Analysis Valid 29/0630 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME from a filament eruption to the southwest of AR3110 around 28/0400 UTC has the potential to arrive at Earth on day 3 (1st). However this has a low confidence analysis due to the lack of STEREO A imagery, and also low confidence in background winds in the current enlil model.

Solar winds are currently declining after the recent fast wind and CME enhancement, with the next coronal hole fast wind anticipated later day 2 (30th) and through day 3 (1st). This is due to recurrent CH27/+ and CH28/+ which brought an extended period of Minor to Moderate geomagnetic storming on the last rotation (Kp 5-6) Similar activity is considered likely on this occasion. There is some uncertainty with Enlil currently suggesting a slower arrival, with weaker winds on day 3-4 (1st and 2nd), however the 27-day persistence is currently preferred. This indicates solar winds will likely rise late on the 30th, before peaking over 600km/s on the day 3 (1st Oct).

Quiet geomagnetic activity with Unsettled intervals possible at first, likely increasing to G1/Minor to G2/Moderate storm with the arrival of the fast wind. This may then increase further day 3 (1st) from any CME arrival, with a chance of G3/Strong Storms. Activity easing to Quiet to Active day 4 (2nd), but still a chance of further G1/Minor Storms.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	70	70	30
Strong	G3	No	1	10	30	1
Severe	G4	No	1	1	5	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
28/0856	Partial	Filament Eruption	NE quadrant	810km/s	01/1000 +/- 10 hours	Likely embedded in CH fast wind. Low confidence (no STEREO A for fit)

Figure 2: Enlil (top) and Ensemble (bottom) shows likely CME arrival – Low confidence due to background winds currently not matching forecast expectations.

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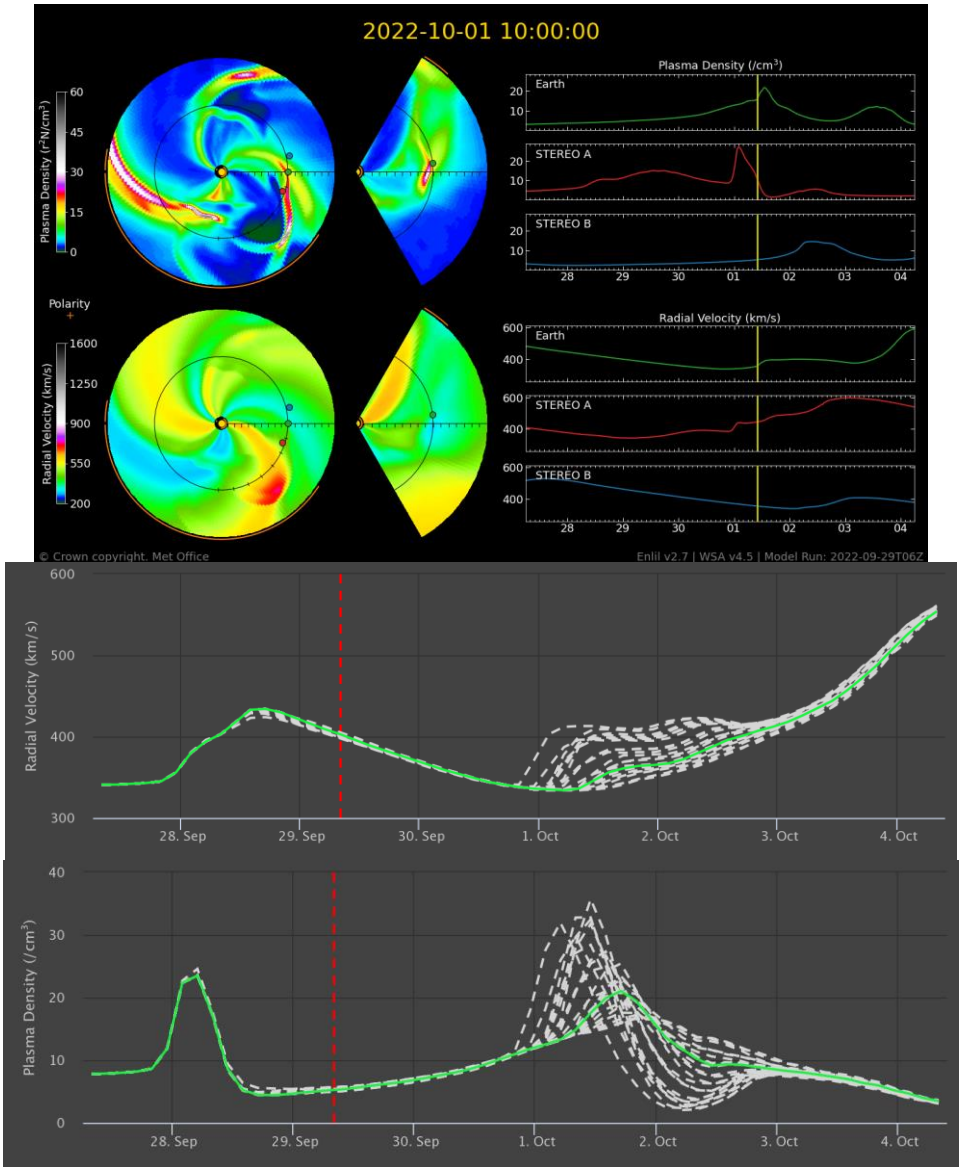
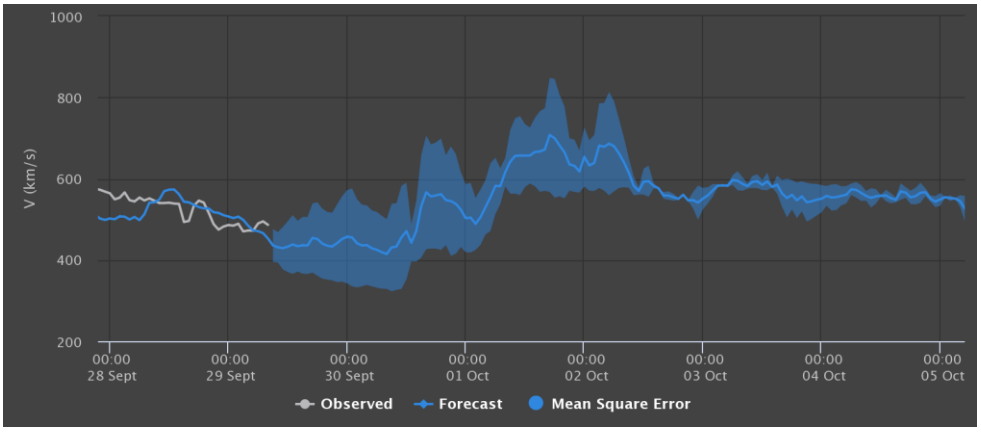


Figure 3: Solar wind 27 day persistence model – suggests increase expected late 30th Sept or 1st Oct.



Radio Blackouts - X-Ray Flares:

Solar activity has been Low in the last 24 hours with the frequency of C-class flares declining and the four sunspots on the disc remaining relatively simple and stable. There is a slight

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chance of M-class flares, slightly increasing as new regions rotate around from the east limb in the coming days.

AR3105 Dao/Beta the southwest disc continues to decay as it approaches the southwest limb. AR3107 Eai/Beta, also in the southwest, has seen its trailer decay to a broad region of pore like spots and is expected to continue simplifying. AR3110 Cho/Beta-Gamma has also seen its trailer region decay, but has also seen a small flux emergence to the southwest of its main leader spot. This will need monitoring for any further growth. Finally AR3111 Hsx/alpha in the northeast is a small and stable uni-polar spot.

Recent CME's observed from just over the limb, along with far-side products, such as helioseismology, and also STEREO A euvi imagery, all suggest a returning active region, ex-AR3098 are expected to rotate onto over the northeast limb by day 3 (1st Oct).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	20	25	30	30
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 4: GOES-16/17 X-Ray Flux.

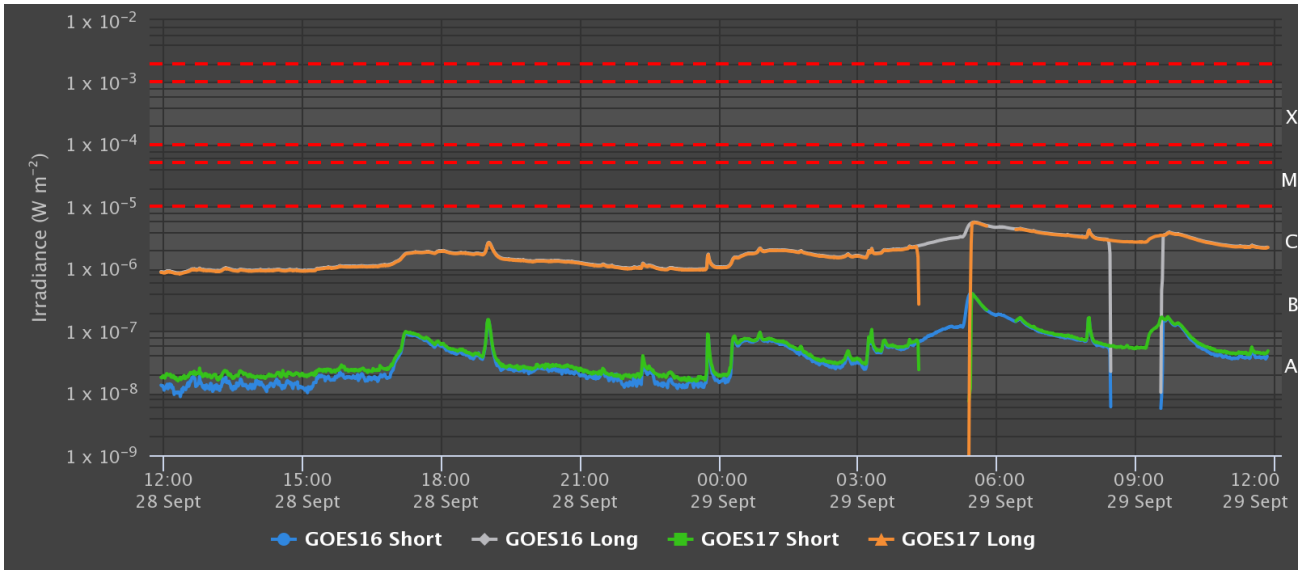

Figure 5: Stanford Seismic Monitoring of the Sun's far side (top) and STEREO-A euvi imagery (bottom) shows returning Ex-3098 region approaching east limb – notice the complexity in the magnetic looping in the SDO AIA 171 imagery (also below).

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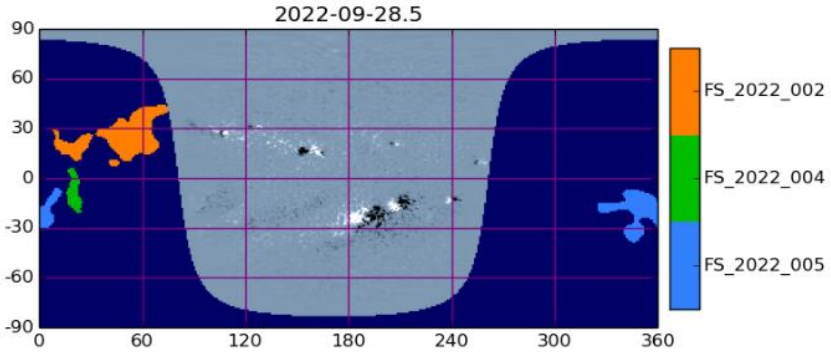

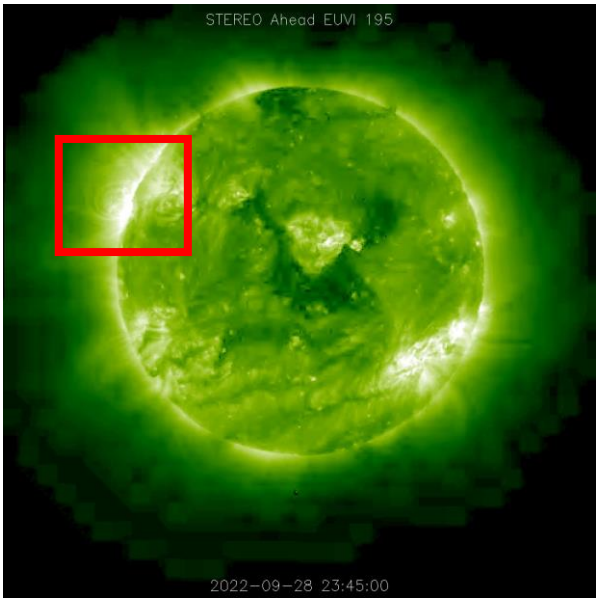

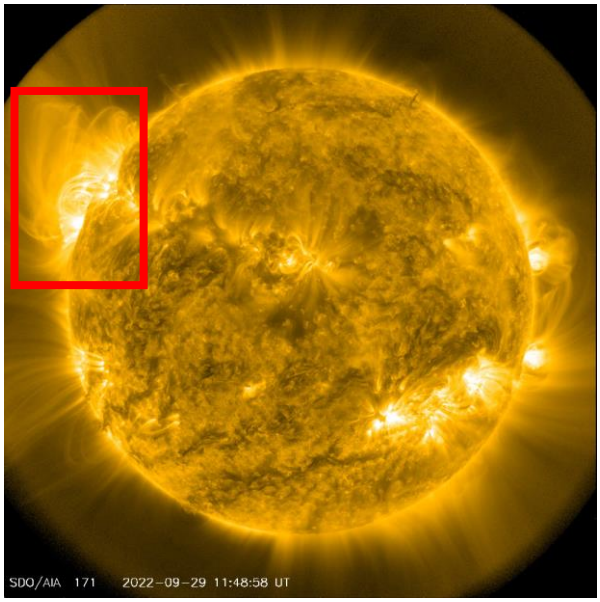

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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10MeV) as observed by GOES16 has declined from very slightly elevated levels to near background. AR3105 and AR3107 have remained relatively stable, with some sign of decay, in the last 24 hours, and while they are moving into an increasingly geoeffective location for proton events, there is only a very slightly above background chance of these producing proton rich flares.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2MeV) electron flux, as observed by GOES-16 has been largely at background levels following the increased geomagnetic activity associated with recent fast wind and CME influences, which have allowed electron populations in the Van Allen belts to be re-distributed. The next significant rise is anticipated to be once the fast wind from CH27/+ and CH28/+ become established likely later day 2 (30th) and through day 3 (1st Oct), although any rise will be complicated by the potential CME arrival on day 3 (1st Oct). High electron flux is expected to become increasingly persistent, with peak values of over 10000 pfu possible, as observed on the previous solar rotation from these features.

The associated electron 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold until at least day 3 (1st). Fluence is then expected to rise, likely above the Active threshold day 4 (2nd) but potentially day 3 (1st). REFM is currently giving good short term trend guidance, but likely poor beyond T+24, increasing fluence values too soon.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	30	70
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	2

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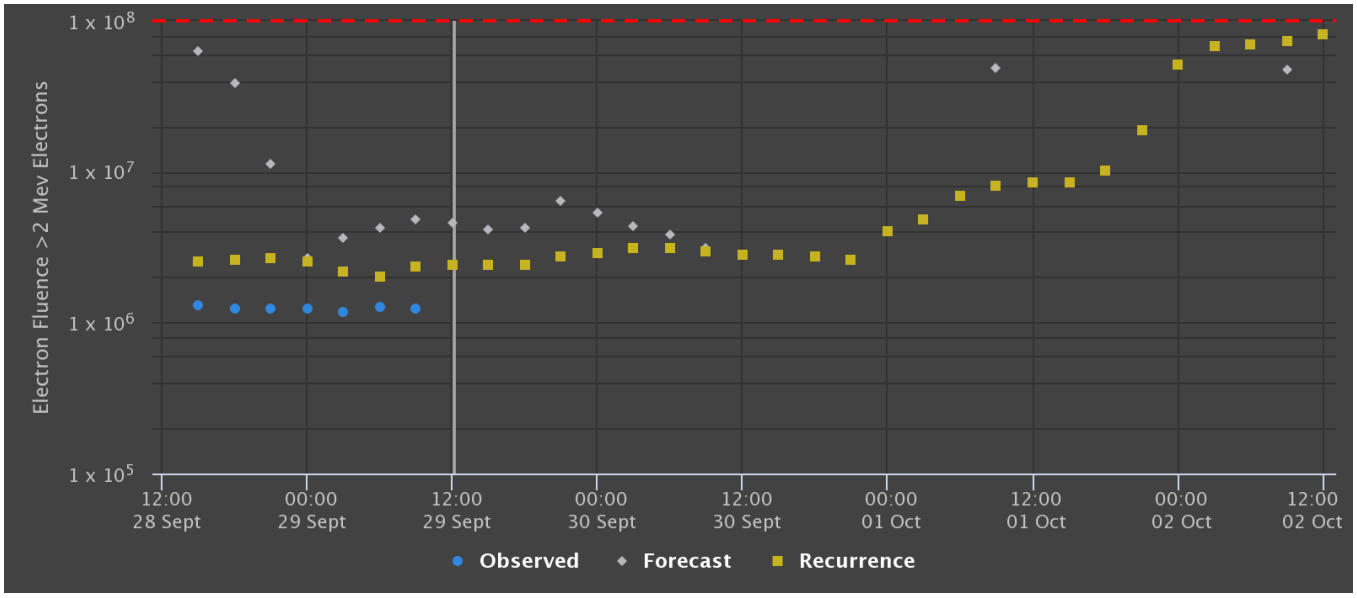
Figure 5: GOES-16 Electron Fluence with REFM – suggests a rising trend by days 3 and 4 (1st and 2nd) possibly to above Active >2 MeV threshold



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